# Space Weather Technical Forecast

Issued on Wednesday, 06 December 2023 at 01:27 Local

**This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales**

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**Space Weather Forecast Headline: Chance of further isolated M-Class flares (R1-R2 Blackouts) throughout. Chance of Active fluence Days 3-4 (08-09 Dec).**

**Analysis of Space Weather Activity over past 24 hours**

**Solar Activity:** Solar activity is currently Moderate with two M-Class flares in the past 24 hours, with a peak M1.5 flare at 05/0644 UTC which appears to have originated from AR3513 rounding the northeast limb. There are currently 9 sunspot regions on the disc, 7 of which are numbered. AR3500 and AR3501 rotated beyond the western limb during the period. Two of the most complex regions on the disc are AR3510 (Dai/Beta) and AR3511 (Dai/Beta-Gamma), close to center disc in the south. Both regions have grown longitudinally with some minor development of new spots. AR3511 has seen intermittent development of delta spots, but none are currently present. Looping has been observed on SDO AIA-0094 imagery between AR3511 and AR3505 suggesting a magnetic connection between these two regions. AR3513 (Csi/Beta) in the northeast quadrant has been the most active region, responsible for both M-Class flares in the past 24 hours. AR3507 (Dso/Beta) in the north close to centre disc, is one of the largest regions on the disc. It has seen the proliferation of a number of small intermediate spots and pores, but is otherwise unchanged. The remaining regions on the visible disc appear small and stable or in slow decay.

A number of CMEs have been evident on coronagraph imagery during the past 24 hours. Analysis and Enlil modelling of these would suggest that none are considered Earth-directed. However, a filament eruption from the northwest disc around 05/2100 UTC appears to have produced a CME. Available imagery is currently limited for confident analysis of this feature, although a glancing blow may be possible on 11 Dec.

**Solar Wind / Geomagnetic Activity:** Solar wind parameters are indicative of the arrival of, and ongoing connection to high-speed stream from coronal hole, CH76/-. Solar wind speeds, as observed by ACE at L1, increased from Elevated levels to Strong around 05/1045 UTC where they have largely remained, with a peak of around 660 km/s. Density was initially above average, measured to be around 10ppcc by DISCOVR. ACE however, has observed below average levels throughout. The Interplanetary Magnetic Field (IMF), Bt, was initially moderate with a peak of 15nT at around 05/0200 UTC. The IMF declined to weak levels at 05/1042 UTC where it has since remained. The north-south component of the IMF (Bz), has been variable and weakly fluctuating between +9/-8 nT. Phi angle has been predominantly negative (towards the Sun).

Resultant Geomagnetic activity was Quiet to Unsettled (Kp 2-3).

**Energetic Particles / Solar Radiation:** GOES16 high energy (greater than 10MeV) proton flux remained at Background levels. GOES16 high energy (greater than 2MeV) electron flux has been mostly Background with a diurnal peak at Moderate. The associated 24-hour fluence has remained below the Active threshold (1e8 integrated pfu) with a slight, steady upwards trend. The observation at 06/0000 UTC was 2.16e6 integrated pfu.

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# Met Office Space Weather Technical Forecast

**Four-Day Space Weather Forecast Summary**

**Solar Activity:** Solar activity is expected to be initially Moderate with a Chance of further isolated M-flares (R1-R2 Blackouts). The risk of M-flares is likely to gradually decline by Days 3-4 (08-09 Dec) in the anticipated absence of new returning regions.

**Solar Wind / Geomagnetic Activity:** A filament eruption that left the Sun around 04/0700 UTC is expected to miss Earth, but there is a very slight chance of a glancing blow later Day 1 (06 Dec) or early Day 2 (07 Dec). There is low confidence in the behaviour of a filament lift-off CME observed at 05/2100 UTC which may have an Earth-directed component. Otherwise, no further CMEs are currently thought to be Earth-directed during the period.

Enhancement of solar winds from the HSS from CH76/- is expected to persist through Day 1 (06 Dec) with winds at Strong levels soon declining to Elevated levels. Winds are expected to slowly return to Slightly Elevated levels Days 2-3 (07-08 Dec), perhaps falling to slow-ambient levels by Day 4 (09 Dec) in the absence of any further CME enhancement.

Geomagnetic activity is expected to be largely Quiet to Unsettled through the forecast period (Kp 1-3). There is a very slight chance late Day 1 or early Day 2 that a glancing blow from a CME may produce an Active (Kp 4) or G1/Minor Geomagnetic Storm interval (Kp 5) but this is considered a low probability

**Energetic Particles / Solar Radiation:** GOES16 high energy proton flux is forecast to remain at background levels with no Solar Radiation Storms expected.

Electron flux is at Background levels. A diurnal increase towards Moderate and possibly High levels is possible by late Day 2 or Day 3 (07-08 Dec) as the electron belts relax as the influence of the HSS wanes. The associated 24 hour electron fluence is expected to remain below the Active threshold, but gradually increasing, with a Chance of exceeding the Active threshold into Day 3 or more likely Day 4 (08-09 Dec).

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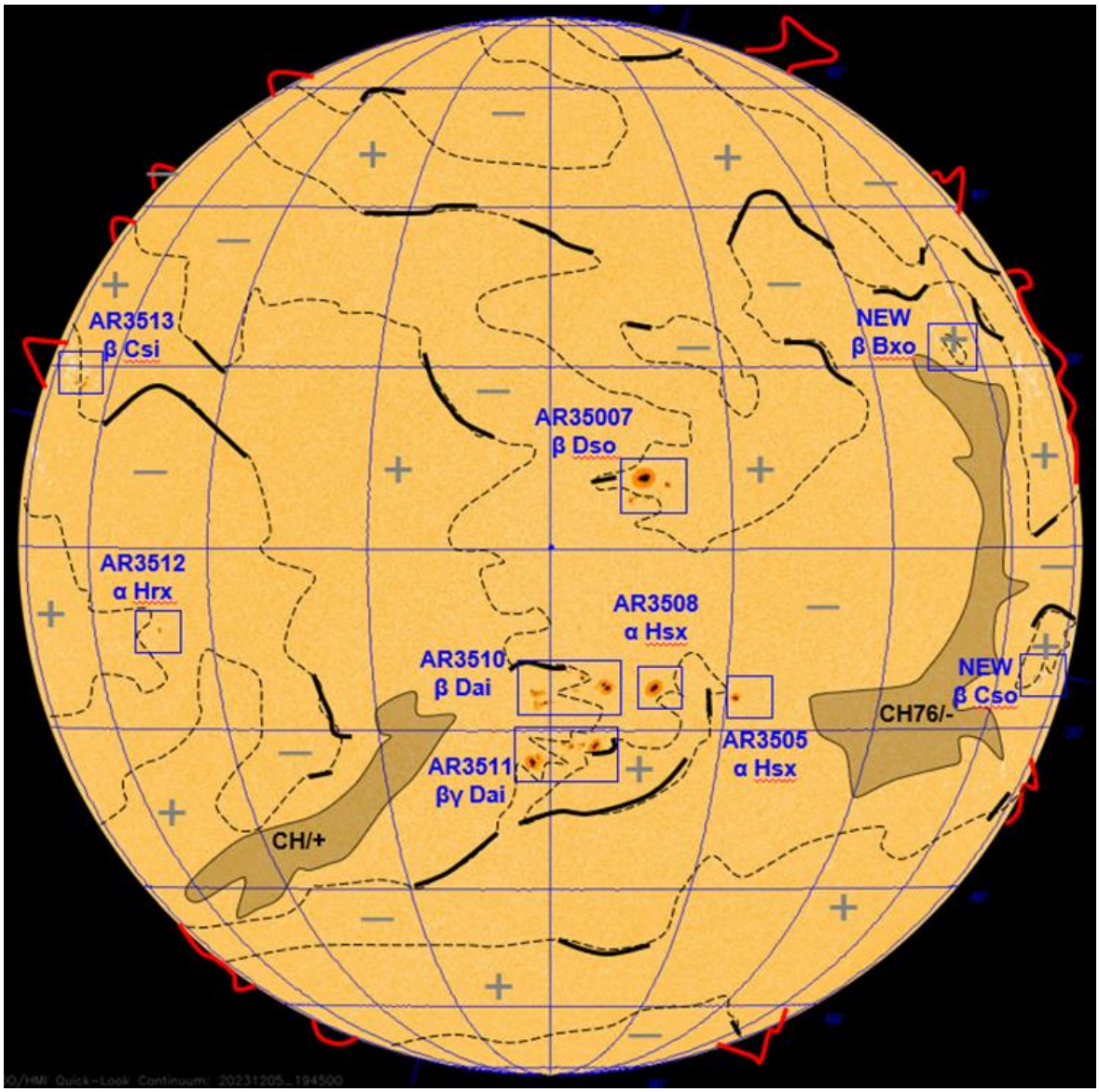
**Figure 1. Solar Analysis Valid 05/2000 UTC.**




**Key:** Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

## Geomagnetic Storms:

The CME produced by a filament eruption around 04/0700 UTC is expected to miss Earth, however, there is a very slight chance of some enhancement and a glancing blow late Day 1 (06 Dec) or early Day 2 (07 Dec). A CME visible on recent coronagraph imagery is likely to have originated from a filament lift-off observed leaving the northwest disc around 05/2100 UTC. Available imagery is currently limited, with rudimentary analysis suggesting the possibility of a glancing blow on 11 Dec. This is considered very low confidence. No further CMEs are currently thought to be Earth-directed during the forecast period.

Solar winds are currently at Strong levels (around 600 km/s) due to the ongoing enhancement from a HSS from CH76/-. Enlil is currently providing good guidance on wind speeds. This coronal hole is a persistent feature and similar in size and position to the previous rotation.

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However, during the previous solar rotation a CME arrival masked the initial influence of the HSS. Solar winds are expected to soon decline to Elevated levels before easing to Slightly Elevated levels by Day 2 (07 Dec). Speeds may decline to background levels by Day 4 (09 Dec). Should the glancing CME arrive on Day, some minor enhancement to wind speeds may be observed.

Geomagnetic activity is expected to be largely Quiet to Unsettled (Kp 1-3). There is a very slight chance late Day 1 or early Day 2 that a glancing blow from a CME may produce an Active (Kp 4) or G1/Minor Geomagnetic Storm interval (Kp 5) but this is considered a low probability, with the majority of Enlil ensemble members modelling a clear miss.

| Geo-Magnetic Storm Probability (Exceedance) | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| Minor or Moderate | G1 to G2 | No | 5 | 5 | 1 | 2 |
| Strong | G3 | No | 1 | 1 | 1 | 1 |
| Severe | G4 | No | 1 | 1 | 1 | 1 |
| Extreme | G5 | No | 1 | 1 | 1 | 1 |

## Geomagnetic Activity - Earthbound Coronal Mass Ejections

| Date/time 21.5R (UTC) | Halo: Full or Partial | Source | Source Location | Estimated Speed | Estimated Arrival Time | Comments |
|---|---|---|---|---|---|---|
| 04/1222 | Partial | Filament near AR3511 | SE | 630 km/s | 07/0500 UTC | Very slight chance of limited glancing impacts |

**Figure 2: MOSWOC Enlil giving reasonable guidance of wind speeds.**

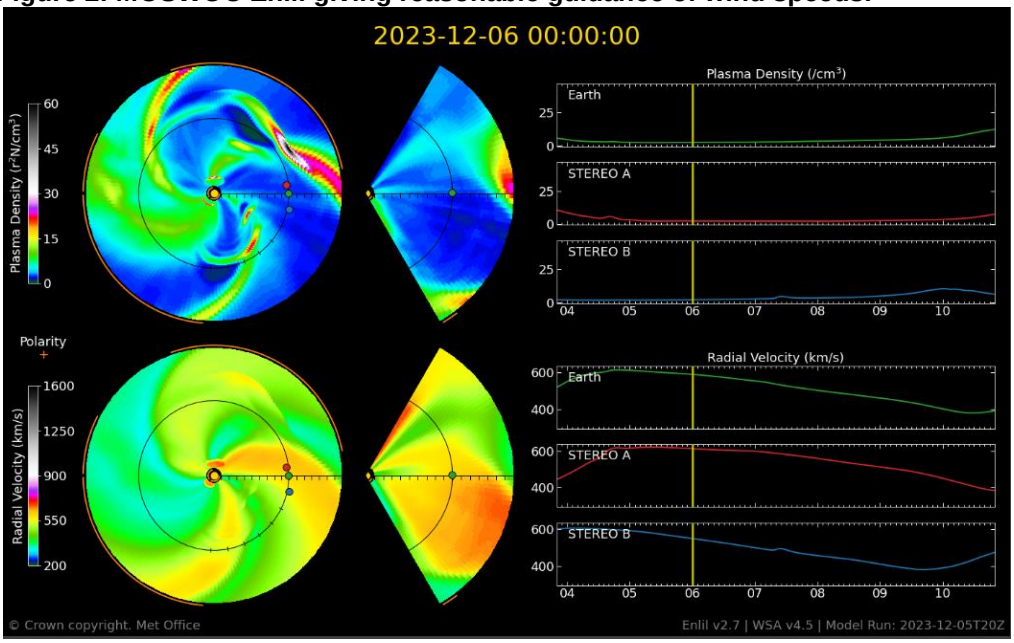


**Figure 3: MOSWOC Enlil ensemble showing spread of solutions for potential glancing blow CME arrival 06-07 Dec.**

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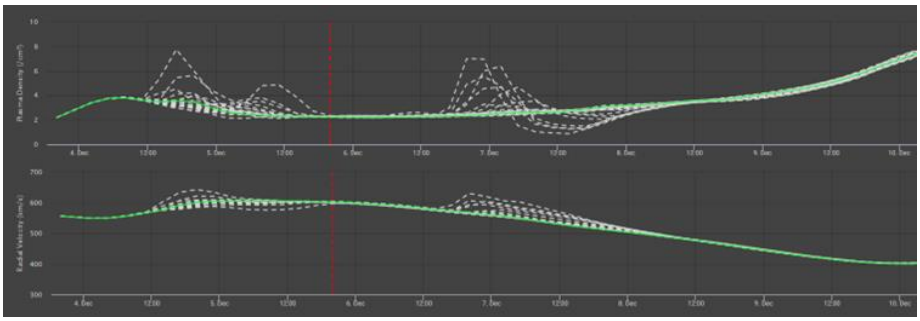


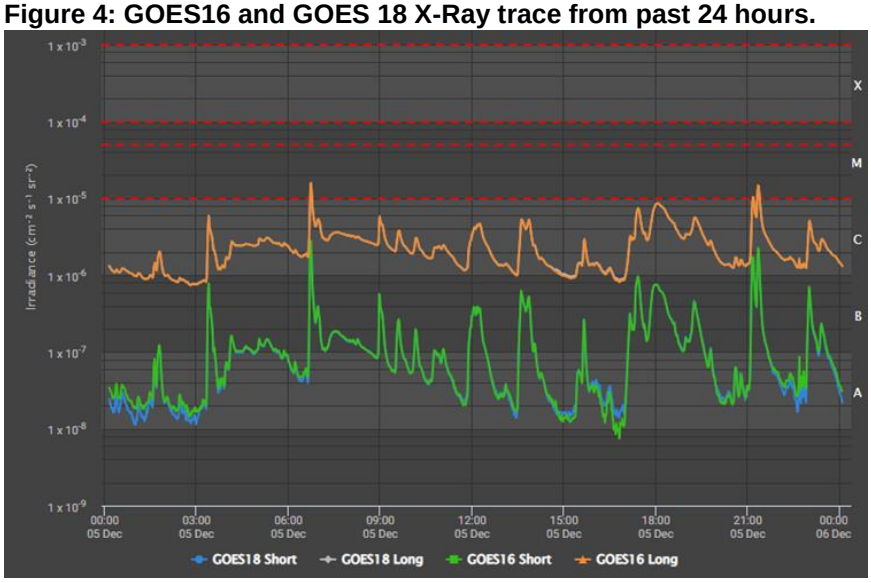
## Radio Blackouts - X-Ray Flares:

Solar activity is currently Moderate, following two M-class flares from AR3513 close to the northeast limb. Background irradiance rose above 1e-6 around 05/0320 UTC to Low levels where it has largely remained. Solar activity may remain Moderate through Days 1-2 (06-07 Dec) with an ongoing Chance of further M-class flares.

As regions AR3510 and AR3511 near south centre disc continue to spread as they rotate westward, it is expected that they will become more stable, with projected reduction in flare contributions. No further significant returning regions are expected to rotate over the eastern horizon in the forecast period.

| X Ray Flares | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) | Day 2 (00-24 UTC) | Day 3 (00-24 UTC) | Day 4 (00-24 UTC) |
|---|---|---|---|---|---|---|
| Probability | | | (%) | (%) | (%) | (%) |
| Active | R1-R2 M Class | Yes | 40 | 40 | 30 | 30 |
| Very Active | R3 to R5 X Class | No | 5 | 5 | 1 | 1 |

**Figure 4: GOES16 and GOES 18 X-Ray trace from past 24 hours.**

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## Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux observed by GOES16 is currently at Background and is expected to remain at this level. There is a slight chance of S1/Minor Storm conditions being reached should any significant flares occur, mainly from AR3510 and AR3511 as they rotate further across the western disc. Probabilities also reflect the uncertainty surrounding development of other regions on the disc.

| Radiation Storms Probability (Exceedance) | Level ($cm^{-2}$ $sr^{-1}$ $s^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| **Active** | **≥ S1** | No | 10 | 10 | 10 | 10 |
| **Very Active** | **≥ S3 *** | No | 1 | 1 | 1 | 1 |
| * S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$) | | | | | | |

## High Energy Electrons Event (≥ 2MeV):

Electron flux is at Background levels, with a diurnal peak at Moderate. The Van Allen belts are still suppressed following recent enhanced geomagnetic activity associated with the HSS from CH76/- and CME glancing blows. An increase towards Moderate to High diurnal levels is possible by later Day 2 or Day 3 (07-08 Dec) as the electron belts relax back towards ambient positions. However, the slight chance of a glancing blow from a CME late Day 1 (06 Dec) or early Day 2 reduces confidence in the forecast.

The associated 24 hour electron fluence is expected to remain below the Active (1e8 integrated pfu) threshold. However, a rising trend is likely to continue, with a more steep increase possible Day 2 onwards (07 Dec) with an increasing chance of exceeding the Active threshold into Day 3 or more likely Day 4 (09 Dec). Current REFM forecast is considered to be providing reasonable guidance.

| GEO Electron Environment Probability (Exceedance) | Level ($cm^{-2}$ $sr^{-1}$ $day^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| **Active** | **≥ 2 MeV ≥ $1x10^8$** | No | 5 | 10 | 30 | 40 |
| **Very Active** | **≥ 2 MeV ≥ $1x10^9$** | No | 1 | 1 | 1 | 1 |

**Figure 5: GOES16 Electron Flux and MOSWOC REFM modelling of Electron Fluence.**

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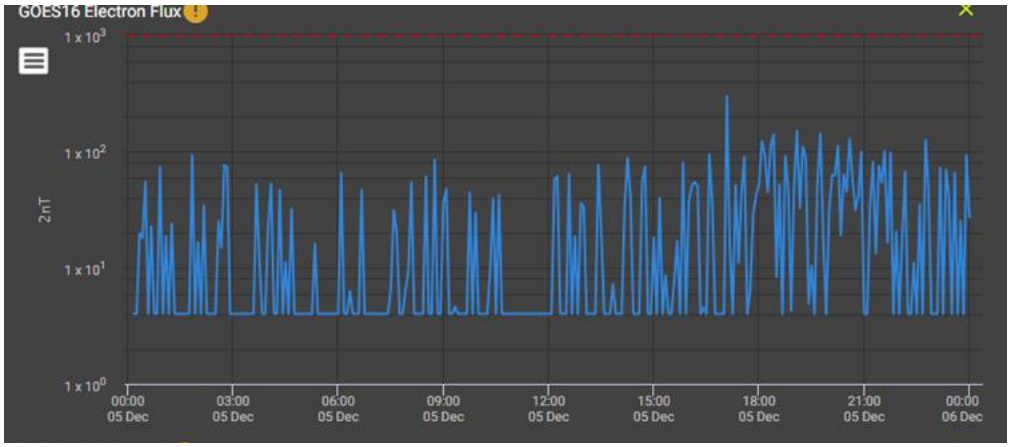


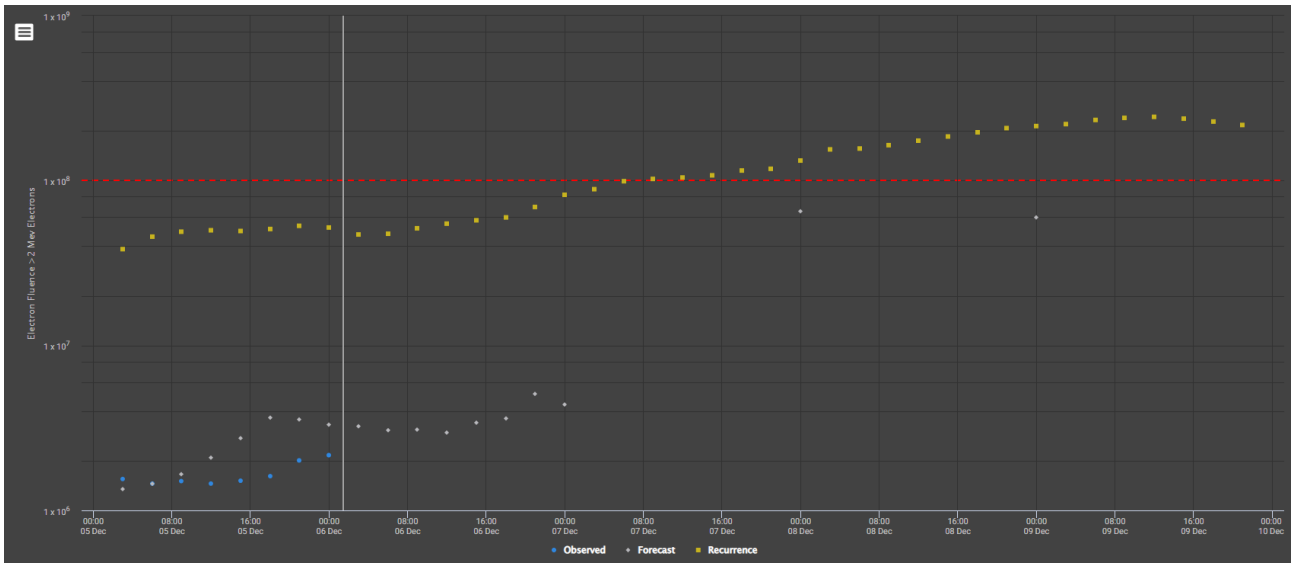


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